

WHAT IS CLAIMED IS:

1. A magnetic resonance imaging (MRI) system providing an MR image of an object to be imaged, comprising:

means for detecting a signal indicative of cardiac temporal phases of the object;

means for performing a pulse sequence toward the object, a unit of imaging defined by the pulse sequence being longer in temporal length than one heart beat represented by the detected signal;

means for acquiring an MR signal from the object in response to performance of the pulse sequence; and

means for producing the MR image based on the acquired MR signal.

2. The MRI system of claim 1, wherein the unit of imaging is a repetition time (TR) of the pulse sequence.

3. The MRI system of claim 1, wherein the pulse sequence consists of a plurality of segmented sequences composing the unit of imaging.

4. The MRI system of claim 1, wherein the pulse sequence includes a pre-sequence including a plurality of divided MT (magnetization transfer) pulses and a data acquisition sequence following the pre-sequence and being applied for acquiring the MR signal.

5. The MRI system of claim 4, wherein the

pre-sequence includes a spoiler pulse dephasing spins of the object and being applied after the plurality of divided MT pulses.

6. A magnetic resonance imaging (MRI) system providing an MR image of a region to be imaged of an object, comprising:

means for applying an MT (magnetization transfer) pulse of which frequency is different than a frequency specifying the region to be imaged;

means for applying a gradient spoiler pulse after the MT pulse applied;

means for scanning the region to be imaged with a pulse sequence to cause an MR signal from the region; and

means for producing the MR image using the MR signal.

7. The MRI system of claim 6, wherein the MT pulse applied by the MT pulse applying means consists of a plurality of divided MT pulses.

8. The MRI system of claim 6, wherein the plurality of divided MT pulses applied by the MT pulse applying means is composed of a plurality of RF (radio frequency) pulses applied slice-non-selectively.

9. The MRI system of claim 6, wherein each of the plurality of divided MT pulses applied by the MT pulse applying means is an RF pulse exciting spins residing

in a slice region determined by a frequency thereof,
comprising means for applying a gradient pulse,
applied concurrently with the RF pulse, for selecting
the slice region.

10. The MRI system of claim 9, wherein each RF
pulse has a shorter applied duration and is given a
smaller flip angle for exciting spins of the slice
region.

11. The MRI system of claim 10, wherein the
gradient spoiler pulse applying means apply the gradient
spoiler pulse in at least one of slice, readout, and
phase-encoding directions spatially set toward the
object.

12. The MRI system of claim 6, wherein the
scanning means has a first scanning means for performing
a first pulse sequence as the pulse sequence toward the
slice region with no MT pulses and gradient spoiler pulse
applied, thereby acquiring a first echo signal as the
MR signal; and a second scanning means for performing
a second pulse sequence as the pulse sequence toward the
slice region with MT pulses and gradient spoiler pulse
applied, thereby acquiring a second echo signal as the
MR signal, and

wherein the MR image producing means produces the
MR image using the first and second echo signals.

13. The MRI system of claim 12, wherein the MT

pulse applied by the MT pulse applying means consists of a plurality of divided MT pulses.

14. The MRI system of claim 13, wherein each of the plurality of divided MT pulses applied by the MT pulse applying means is an RF pulse exciting spins residing in a slice region determined by a frequency thereof, comprising means for applying a gradient pulse, applied concurrently with the RF pulse, for selecting the slice region.

15. The MRI system of claim 14, wherein each RF pulse has a shorter applied duration and is given a smaller flip angle for exciting spins of the slice region.

16. The MRI system of claim 15, wherein the MT pulse applying means apply the plurality of RF pulses aligning juxtaposedly along a temporal axis.

17. The MRI system of claim 16, wherein the gradient pulse applying means turn on and off the gradient pulse in response to first and last transitions of each of the plurality of RF pulses.

18. The MRI system of claim 16, wherein the gradient pulse applying means turn on and off the gradient pulse in response to only first and last transitions of all the plurality of RF pulses.

19. The MRI system of claim 15, wherein the gradient spoiler pulse applying means apply the gradient spoiler pulse in at least one of slice, readout, and phase-encoding directions spatially set toward the object.

20. The MRI system of claim 16, wherein the MR image producing means includes means for performing a difference operation between image data based on the first and second echo signals.

21. The MRI system of claim 11, comprising means for instructing the object to perform a breath hold during scanning performed by the first and second scanning means.

22. The MRI system of claim 11, comprising means for detecting a signal indicative of cardiac temporal phases of the object, wherein each of the first and second scanning means comprise means for performing the first and second means in synchronism with the detected signal.

23. The MRI system of claim 11, wherein the first and second pulse sequences are composed of the same type of pulse sequence according to either one of a two-dimensional scan or a three-dimensional scan, said pulse sequence being based on one of SE (Spin Echo), FSE (Fast SE), FASE (Fast Asymmetric SE), FE (Gradient Field Echo), FFE (Fast FE), segmented FFE, and EPI (Echo Planar Imaging) methods.

24. The MRI system of claim 11, wherein the region to be imaged is a field of the lungs of the object.

25. A magnetic resonance imaging method of providing an MR (magnetic resonance) image of a region to be imaged of an object; the method comprising the steps of:

applying an MT (magnetization transfer) pulse of which frequency is different than a frequency specifying the region to be imaged;

applying a gradient spoiler pulse after the MT pulse applied;

scanning the region to be imaged with a pulse sequence to cause an MR signal from the region; and

producing the MR image using the MR signal.

26. A magnetic resonance imaging method of acquiring from an object an MR (magnetic resonance) signal based on a magnetic resonance phenomenon of at least two kinds of nuclear pools coupled with each other by at least one of a chemical exchange phenomenon or a cross relaxation phenomenon in the object, comprising the steps of:

applying in turn a plurality of divided MT pulses to a region selected in the object, thereby decoupling the coupling of the at least two kinds of nuclear pools;

applying a gradient spoiler pulse to the decoupled nuclear pools; and

scanning, with a pulse sequence, another region

to be imaged different in position from the MT pulse applied region as well as acquiring the MR signal from the another region.

27. The imaging method of claim 26, wherein the at least two kinds of nuclear pools are nuclear pools of free water and nuclear pools of macromolecules of the object.

28. A magnetic resonance imaging (MRI) system providing an MR image of a region to be imaged of an object, comprising:

means for performing a pulse sequence including a pre-sequence for applying an MT (magnetization transfer) pulse causing MT effects in spins of the object and an SE(spin echo)-system data acquisition sequence, which follows the pre-sequence, for generating a plurality of echo signals in response to one time of excitation of the spins using an RF (radio frequency) magnetic field;

means for acquiring the plurality of echo signals; and

means for producing the MR image based on the acquired echo signals.

29. The MRI system of claim 28, wherein the pulse sequence is applied to either one of a three-dimensional volume region or a two-dimensional slab and formed to perform at least one time of excitation within a repetition time of imaging.

30. The MRI system of claim 29, wherein the MT pulse consists of a plurality of divided MT pulses composing a pulse train, at least one factor among the number of divided MT pulses, a flip angle assigned to each divided MT pulse, and an off-resonance frequency assigned to each divided MT pulse being changeable.

31. The MRI system of claim 29, wherein the pre-sequence includes a fat-suppression pulse applied after the MT pulse applied and suppressing an echo signal to be generated from fat of the object.

32. The MRI system of claim 31, wherein the pre-sequence includes a gradient spoiler pulse being applied after the fat-suppression pulse applied and dephasing spins of the object.

33. The MRI system of claim 31, wherein at least one of RF (radio frequency) pulses forming the MT pulse and the fat-suppression pulse are applied slice-selectively or slice-non-selectively.

34. The MRI system of claim 31, wherein at least one of RF (radio frequency) pulses forming the MT pulse and the fat-suppression pulse are applied together with a slice gradient defining the region to be imaged.

35. The MRI system of claim 29, further comprising

means for detecting a signal indicative of cardiac temporal phases of the object;

means for synchronizing start of the pulse sequence with a reference wave of the detected signal; and

means for instructing the object to perform an intermittent breath hold according to the detected signal.

36. The MRI system of claim 35, wherein the detecting means detect an ECG (electrocardiogram) signal of the object as the signal indicative of cardiac temporal phases thereof.

37. The MRI system of claim 36, wherein the breath-hold instructing means include a gradient pulse incorporated into the pulse sequence, the gradient pulse generating a sound in a gantry of the MRI system when applied.

38. The MRI system of claim 37, wherein the synchronizing means has means for delaying by a given amount of time the start of the pulse sequence from the reference wave of the ECG signal, and the breath-hold instructing means has means for applying the gradient pulse to generate the sound during an interval of the delay time.

39. The MRI system of claim 37, wherein the synchronizing means has means for delaying by a given

amount of time the start of the pulse sequence from the reference wave of the ECG signal, and the breath-hold instructing means has means for applying the gradient pulse to generate the sound during an interval existing between the two adjacent pulse sequences intermittently performed and being determined from a time of the reference wave.

40. The MRI system of claim 37, wherein the breath-hold instructing means are means that instructing the object to perform the intermittent breath hold using sounds generated by applying the gradient pulse together with messages including at least one of a voice message generated by computer synthesis and a visual signal generated by a given element.

41. The MRI system of claim 37, wherein the breath-hold instructing means is constructed to change at least one parameter among a switching frequency of the gradient pulse, an applied magnitude thereof, a switching duration thereof, and the number of pulses included in the gradient pulse.

42. The MRI system of claim 28, wherein the data acquisition sequence is formed by a train of pulses in conformity with an FSE (Fast SE) sequence employing a half-Fourier scan.

43. The MRI system of claim 28, wherein the SE-system data acquisition sequence includes a plurality

of refocus RF pulses of which each interval corresponding to an ETS (Echo Train Spacing) is 6 msec or less.

44. The MRI system of claim 28, wherein the SE-system data acquisition sequence includes a plurality of RF pulses producing a plurality of echoes of which ETS (Echo Train Spacing) is 8 msec or less.

45. A magnetic resonance imaging system comprising:

means for detecting an ECG (electrocardiogram) signal from the object;

means for performing a pulse sequence to acquire MR data with an object, including means for synchronizing start of the pulse sequence according to the ECG signal;

means for instructing the object an intermittent breath hold according to the ECG signal; and

means for producing an MR (magnetic resonance) image through acquiring MR data generated in response to the pulse sequence performed,

wherein the breath-hold instructing means include a gradient pulse incorporated into the pulse sequence, the gradient pulse generating a sound in a gantry of the MRI system when applied.

46. A magnetic resonance imaging (MRI) system comprising:

means for acquiring MR (magnetic resonance) data from an object by performing a pulse sequence toward the object; and

means for informing the object of timing necessary for an intermittent breath hold to be performed by the object using a sound generated by applying a gradient pulse.

47. The MRI system of claim 46, wherein the pulse sequence includes the gradient pulse to generate the sound and a data acquisition sequence for acquiring the MR data.

48. The MRI system of claim 47, wherein the gradient pulse is set to be applied during an interval to inform the object of a free breath period.

49. The MRI system of claim 48, wherein the gradient pulse consists of a plurality of pulses to be sounded of which parameters are set on the basis of a natural breath state of the object.

50. The MRI system of claim 48, wherein the gradient pulse consists of a plurality of pulses to be sounded, wherein the number, frequency, and magnitude of pulses are changeable.

51. The MRI system of claim 46, comprising means for detecting an ECG (electrocardiogram) signal of the object and means for synchronizing start of the pulse sequence with the ECG signal.

52. The MRI system of claim 46, wherein the

breath-hold instructing means is constructed to provide information about the intermittent breath hold, the information including the sound generated by applying the gradient pulse and a voice message generated in an automatic voice generator.

53. The MRI system of claim 46, wherein the pulse sequence is formed on the basis of one of a 3D(three-dimensional)-MRCP (MR cholangiopancreatography) method, a 3D-SPEED (Swap Phase Encode Extended Data) method, a 3D-FBI (Fresh Blood Imaging), and a 3D-segmented FFE (Fast FE) method.

54. A magnetic resonance imaging (MRI) system in which MR (magnetic resonance) data are acquired from an object by performing a pulse sequence toward the object, comprising:

- a unit for generating a gradient to be applied to the object;

- a unit for transmitting and receiving RF (radio frequency) signals to and from the object; and

- a sequencer for controlling the gradient generating unit and the transmitting/receiving unit in order to perform the pulse sequence toward the object,

- wherein the sequencer stores an algorithm for the realizing the pulse sequence including a pre-sequence for applying an MT (magnetization transfer) pulse causing MT effects in spins of the object and an SE(spin echo)-system data acquisition sequence, which follows the pre-sequence, for generating a plurality of echo

signals in response to one time of excitation of the spins using an RF magnetic field.

55. A magnetic resonance (MR) imaging method of providing an MR image of an object, comprising the steps of:

performing a pulse sequence including a pre-sequence for applying an MT (magnetization transfer) pulse causing MT effects in spins of the object and an SE(spin echo)-system data acquisition sequence, which follows the pre-sequence, for generating a plurality of echo signals in response to one time of excitation of the spins using an RF (radio frequency) magnetic field; and

producing the MR image from the plurality of echo signals.